Remote sensing for spatial ecology

Agnès BEGUE (CIRAD, UMR TETIS)

- **Many references on remote sensing for spatial ecology**
  - « Remote sensing » and « ecology » (121)
  - « Remote sensing » and « habitat » (108)
  - « Remote sensing » and « biodiversity » (37)
  - « Remote sensing » and « pest » (8)
  - « Remote sensing » and « insect » (7)
  - …

- **Applications in spatial ecology**
  - Land cover classification (qualitative RS) and spatial analysis
  - Land surface parameters (quantitative RS) and modeling
  - Land surface change (change detection and trend analysis)

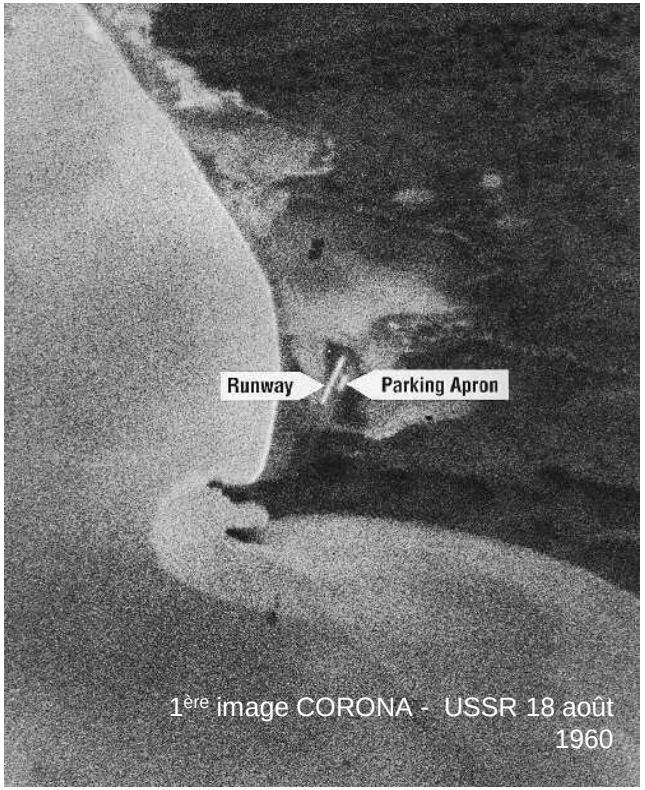
- **Remote sensing offer**
  - Satellite remote sensing / Aerial remote sensing

- **Remote sensing information content**
  - Spectral, spatial, temporal dimensions…

The remote sensing offer

A more than 150-year old technique !

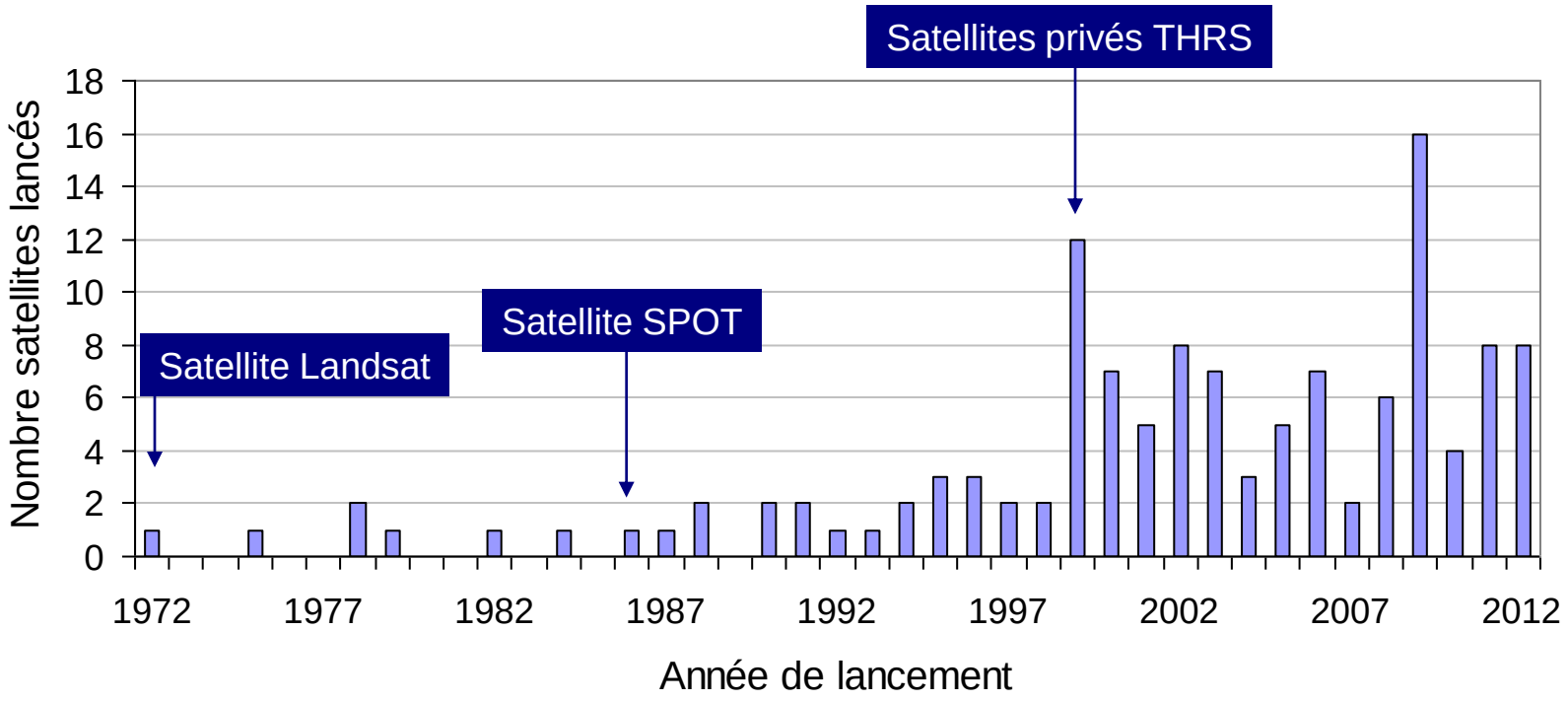
1859	Invention of photography (1839) - First known aerial photo (Tournachon - "Nadar", France) - First known saved aerial photo (1860 - James Wallace Black.)



1ère image CORONA - USSR 18 août 1960

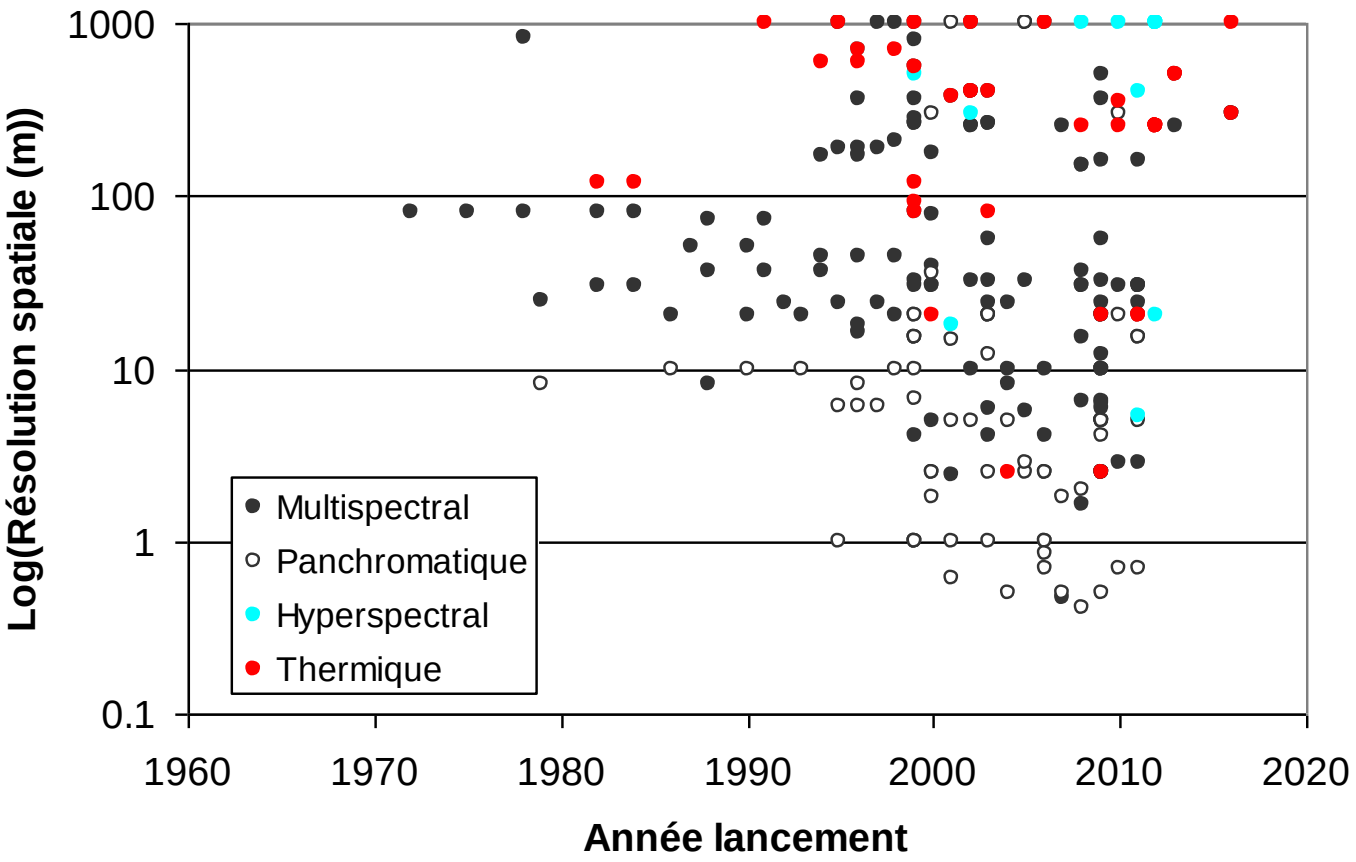
1960s	First meteorological and military satellites Nimbus (1964) / Corona (1960)

Satellite remote sensing (1/2)



In the optical domain :http://gdsc.nlr.nl/gdsc/information/earth_observation/satellite_database (janv. 2010)

Satellite remote sensing (2/2)



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How to choose a satellite image (which images for which application)?

Study site	Image size
Objects/classes to identify	Spatial resolution
Surface parameters to quantify	Spectral band
Time period and frequency	Archive/Programming (tasking)
Budget	Image cost
Partnership	Image licence
Technical skills / ancillary data	Image level

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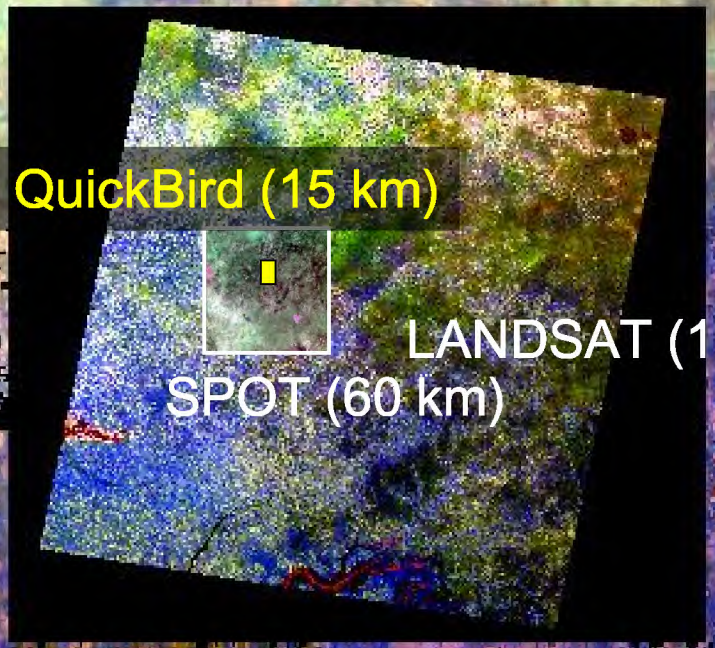
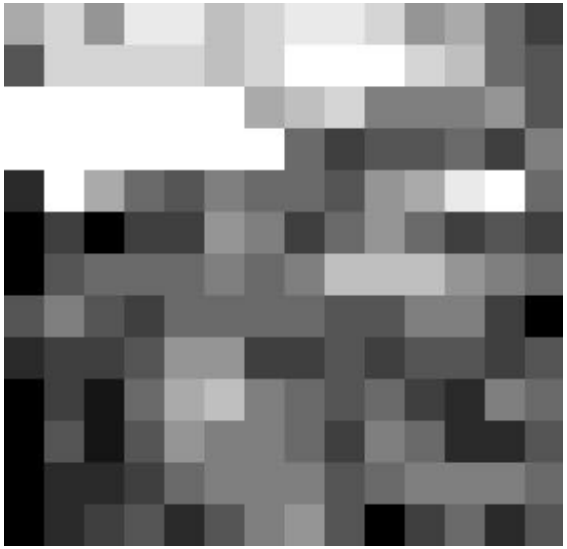
VEGETATION (3200 km)



- **Echelle régionale (10^6 km²)**
  - SPOT/VEGETATION
  - MODIS
- **Echelle locale (10 -> 10^4 km²)**
  - SPOT/LANDSAT (10^3 / 10^4 km²)
  - QuickBird/Ikonos (centaine km²)
  - Photos aériennes (dizaine km²)

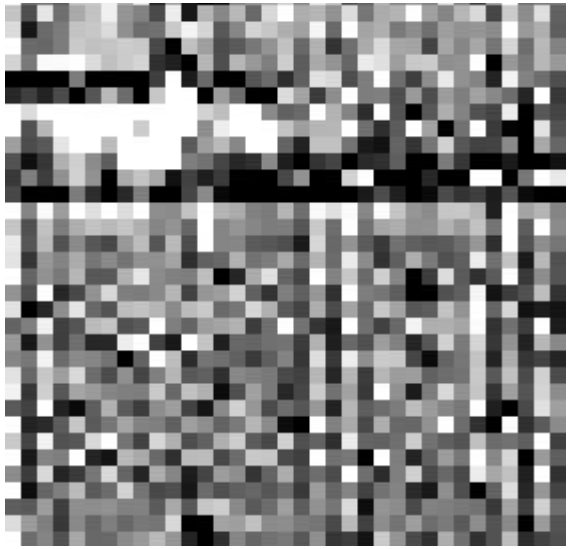
Spatial resolution

SPOT XS = 20m



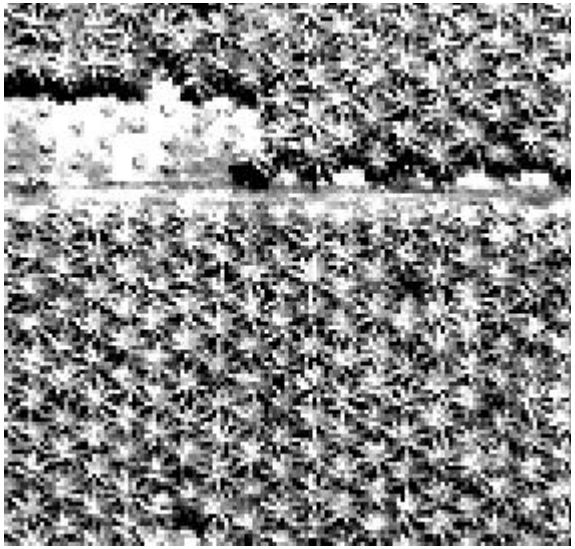
10 palm trees

Ikonos MS = 4m



1-2 palm trees

Ikonos P = 1m

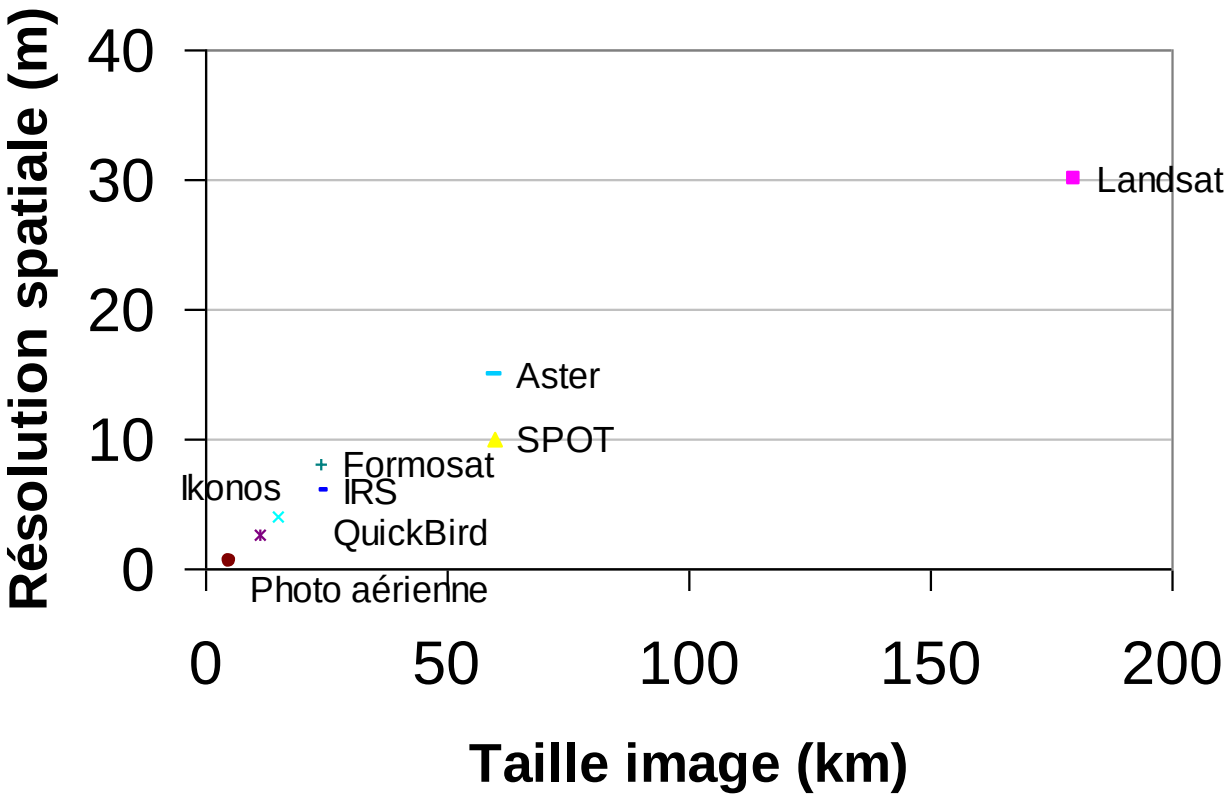


<1 palm tree

For a thematic question,
the best spatial resolution is not always the finest.

Spatial resolution vs Image size

Modis



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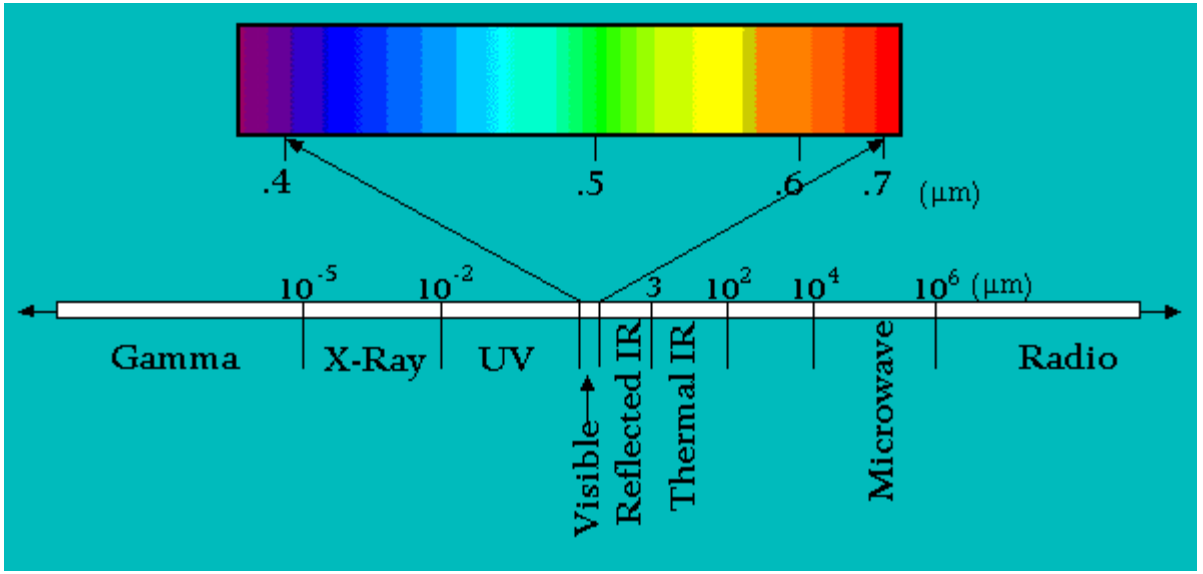
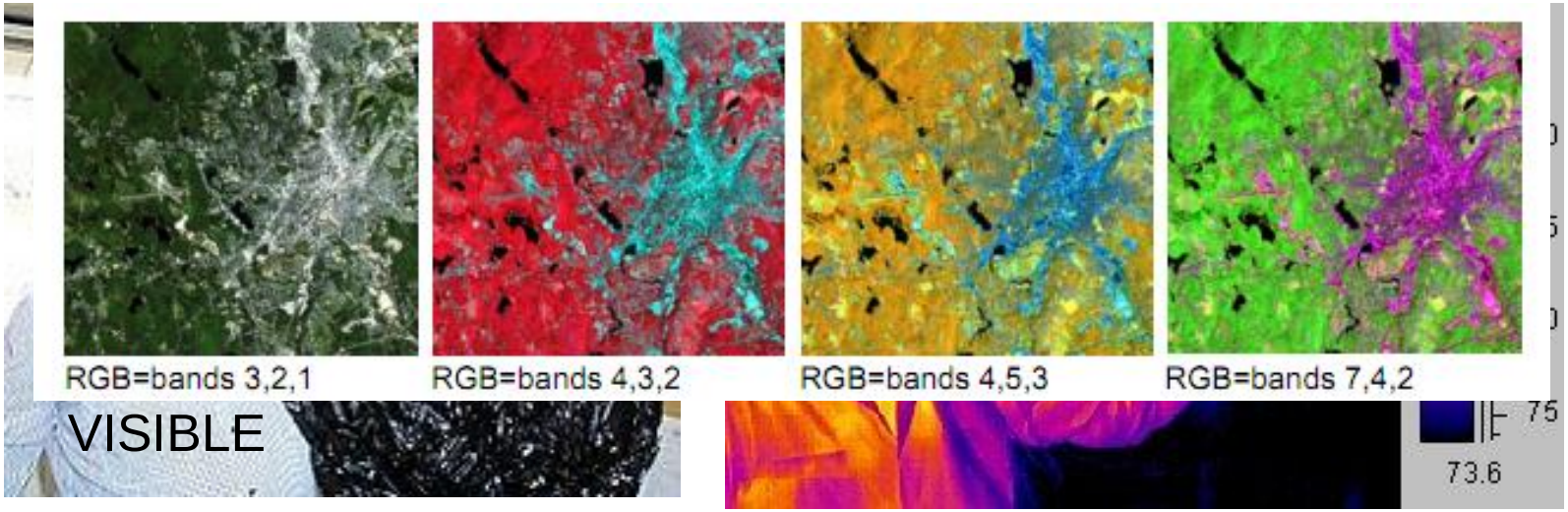
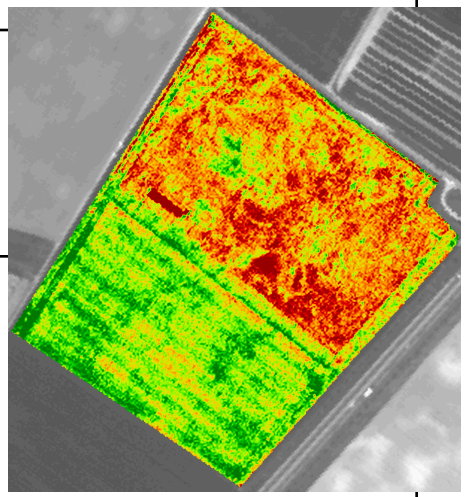
Spectral bands (1/2)

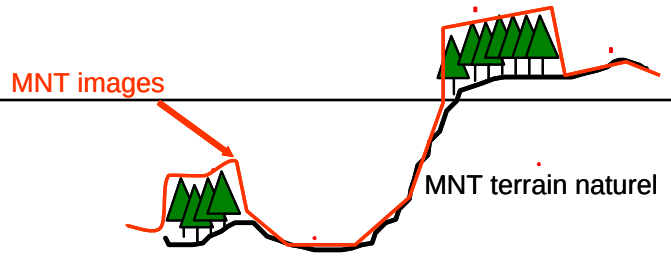




Spectral bands (2/2)

Surface parameters	Spectral band
Biomass, Leaf area, vegetation cover …	Visible + Near Infrared (large spectral bands) *= multi-spectral*
Plant N content, soil organic matter, soil components …	Visible + Near Infrared (narrow spectral bands) *= Super – hyper-spectral*
Evapo-transpiration Urban temperature …	*Thermal Infrared*
Soil moisture Surface roughness …	Micro-waves *= radar*
Tree height, DEM… DSM	Radar altimetry





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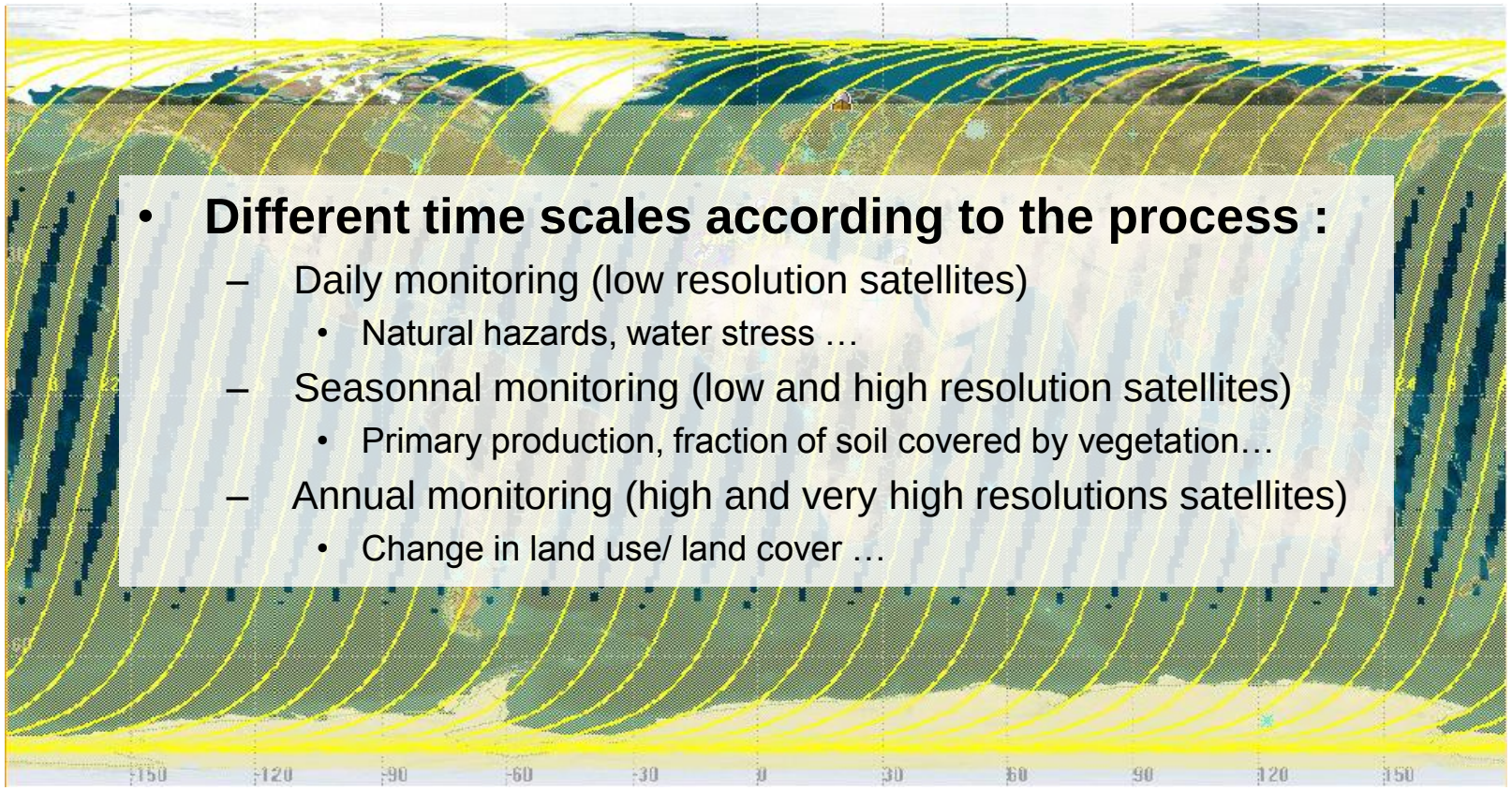
Archive or tasking

- **Archives :**
  - Landsat (**1972**), SPOT (1986), SPOT5 (2002)
  - QuickBird (2001), Ikonos (1999)
  - NOAA (**1982**), VEGETATION (1998), MODIS (1999)
  - Aerial photos …
- **Tasking :**
  - Only some satellites are programmable : SPOT, THRS
  - Cost >
  - Not garanteed (tasking conflicts, clouds…)

Acquisition frequency

- **The acquisition frequency depends on :**
  - Satellite orbital parameters + Target latitude
  - Sensor field of view + Sensor depointing capacities



- **Different time scales according to the process :**
  - Daily monitoring (low resolution satellites)
    - Natural hazards, water stress …
  - Seasonnal monitoring (low and high resolution satellites)
    - Primary production, fraction of soil covered by vegetation…
  - Annual monitoring (high and very high resolutions satellites)
    - Change in land use/ land cover …

Ground Track after 7 Days

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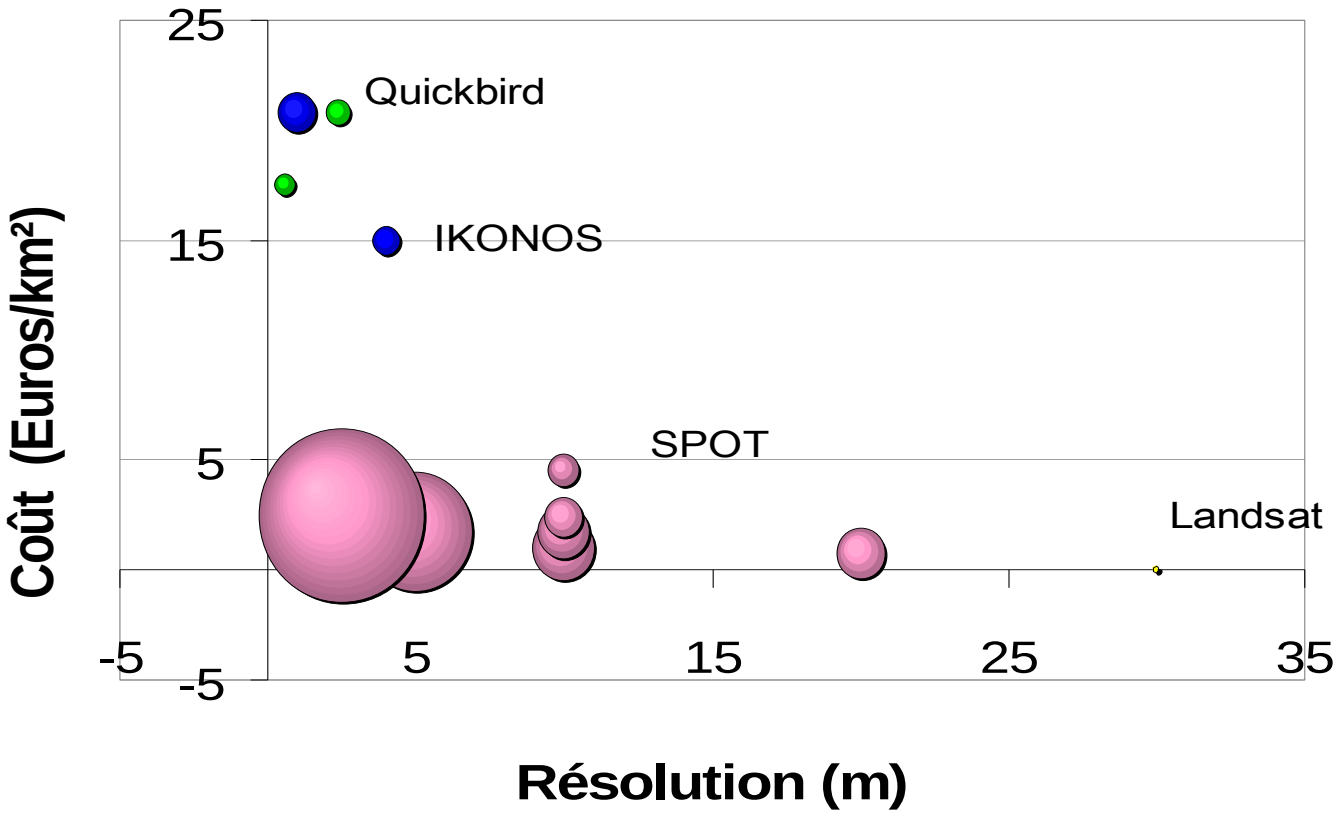
Image cost

Cost = f(Archive/tasking, resolution, image size, pre-processing level…)



Satellite image cost (tasking)

(the size of the circle is proportional to the minimum order in €)

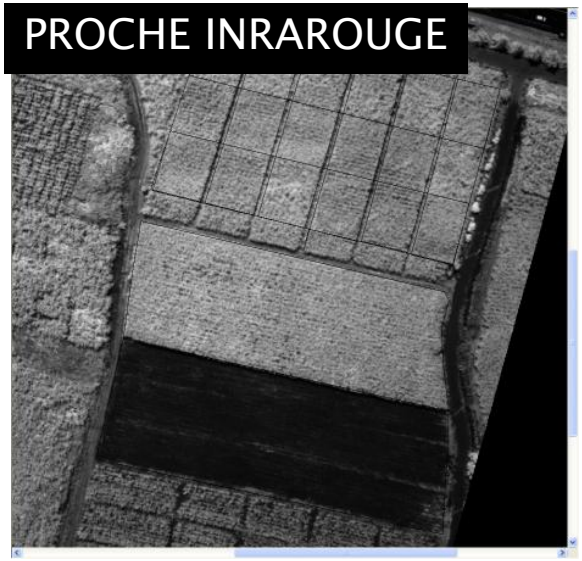
Aerial remote sensing (1/5)

Ultra-light aircraft

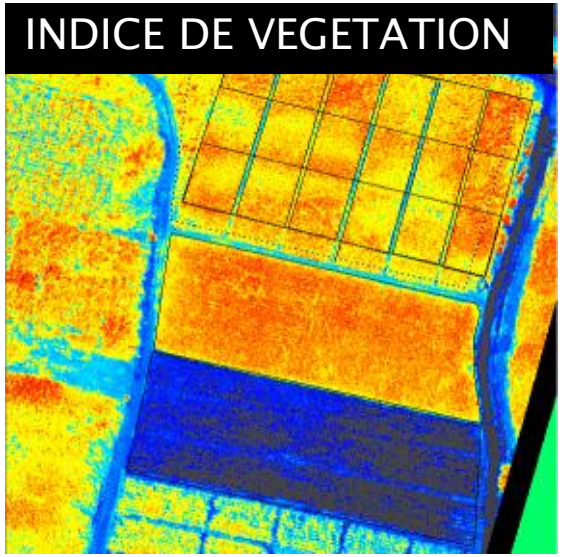
Aerial remote sensing (2/5)

VISIBLE

PROCHE INRAROUGE

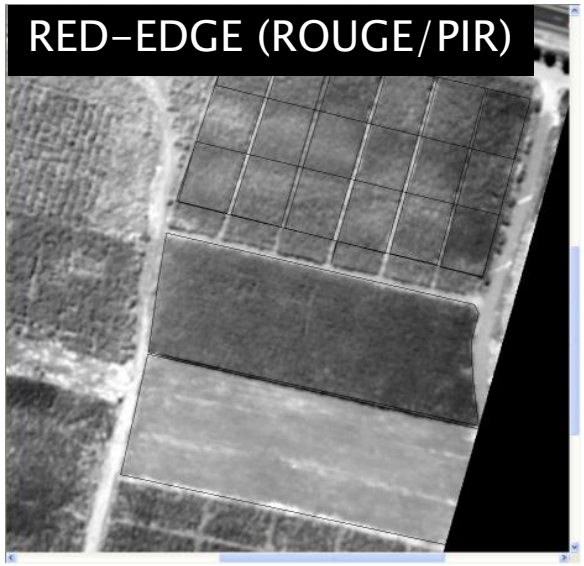


INDICE DE VEGETATION

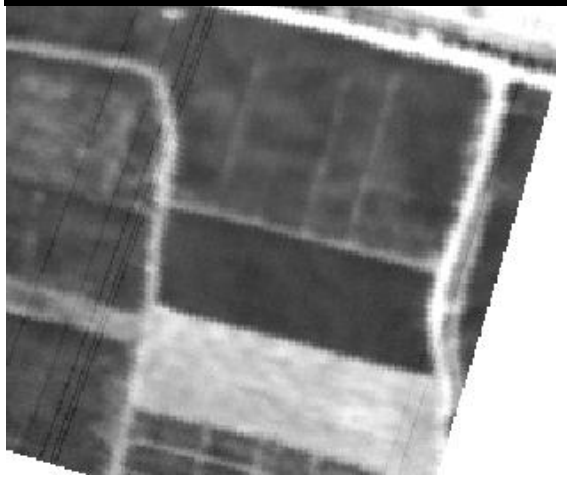


Site de La Mare, le 19 avril 2006

RED-EDGE (ROUGE/PIR)



INFRAROUGE THERMIQUE



V. Lebourgeois et al. (2006)

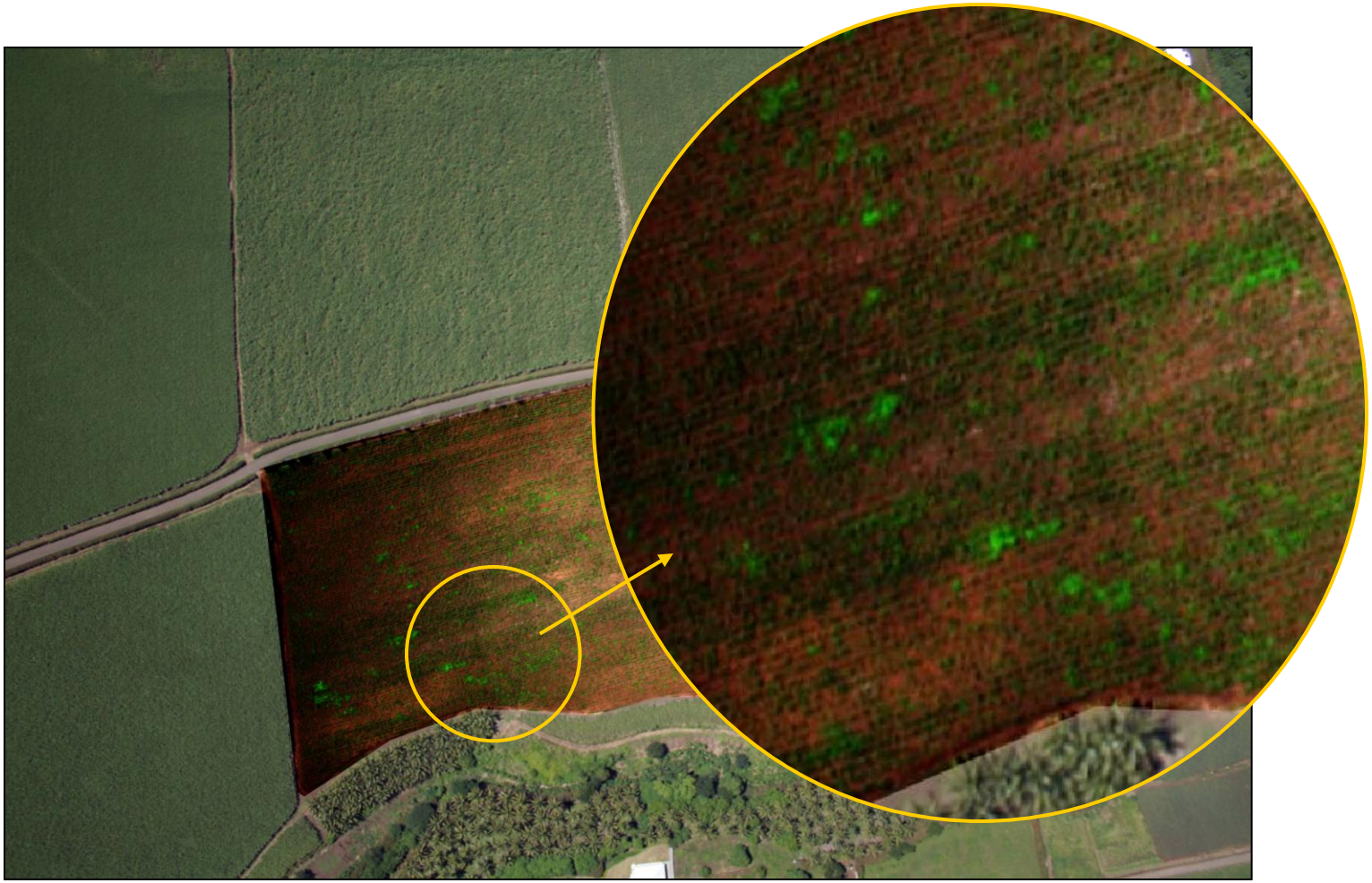
Aerial remote sensing (3/5)

- Sugarcane

V. Lebourgeois et al. (2006)

Aerial remote sensing (4/5)

- Detection of weeds



V. Lebourgeois et al. (2006)

Aerial remote sensing (5/5)

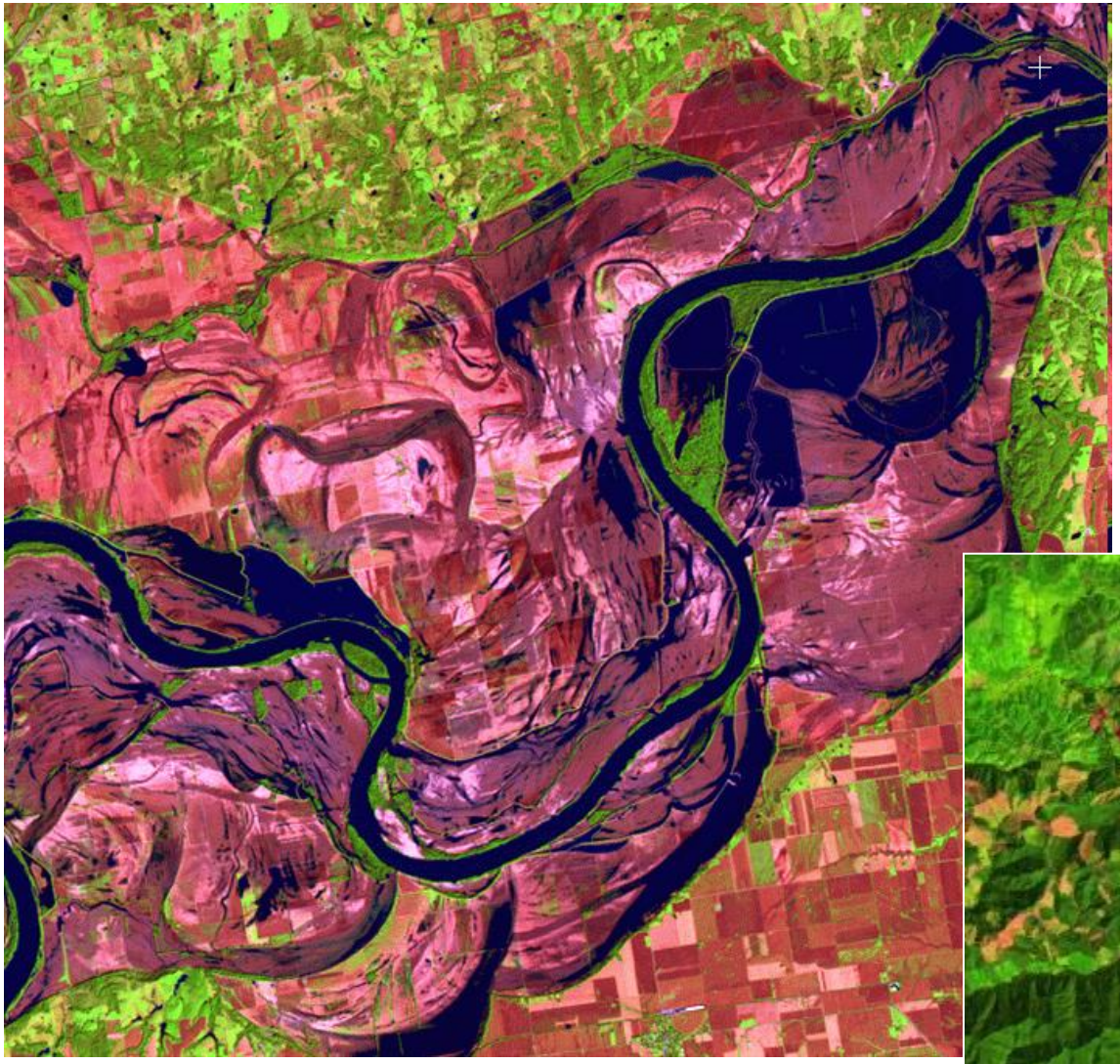
- Precision farming

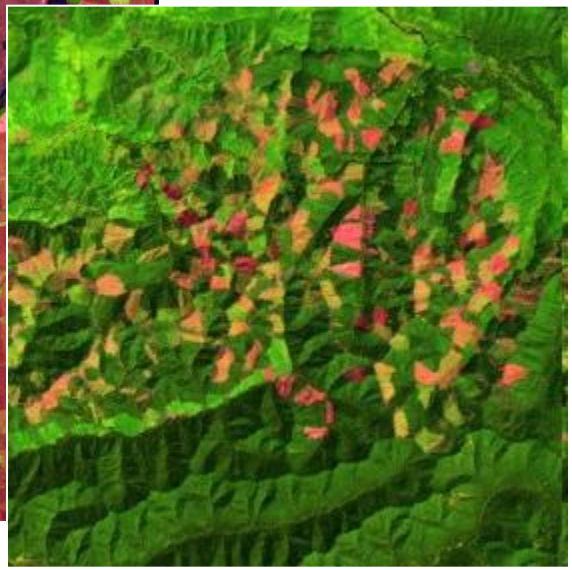
Characterizing the
INSIDE PLOT
HETEROGENEITY

V. Lebourgeois et al. (2006)

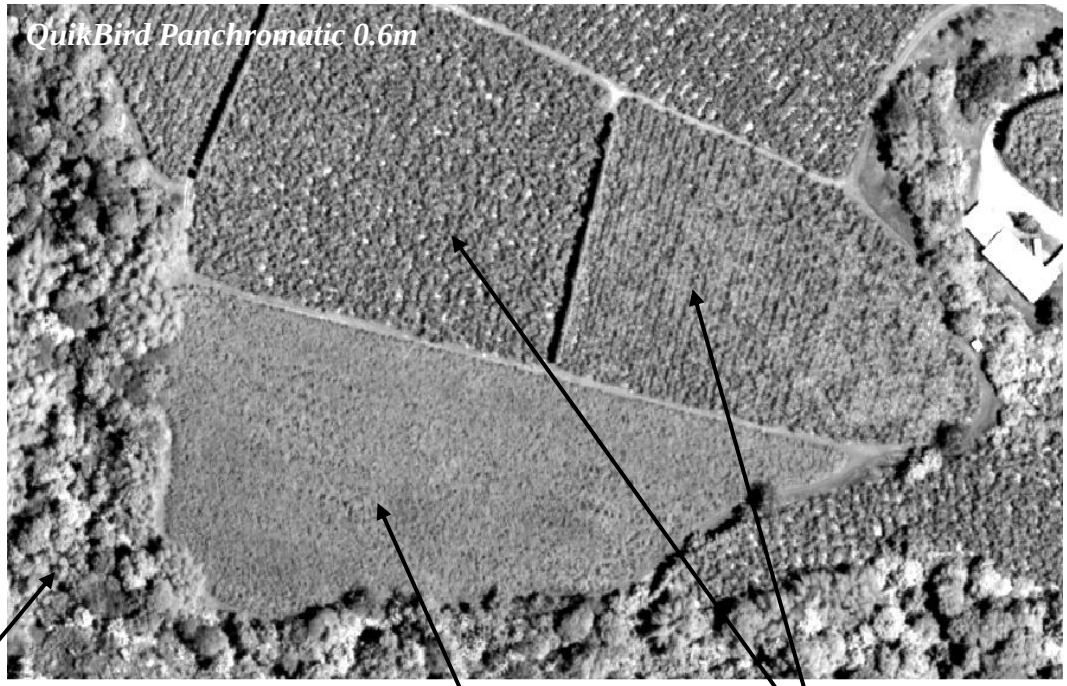
The remote sensing information content

Spectral information





Textural Information



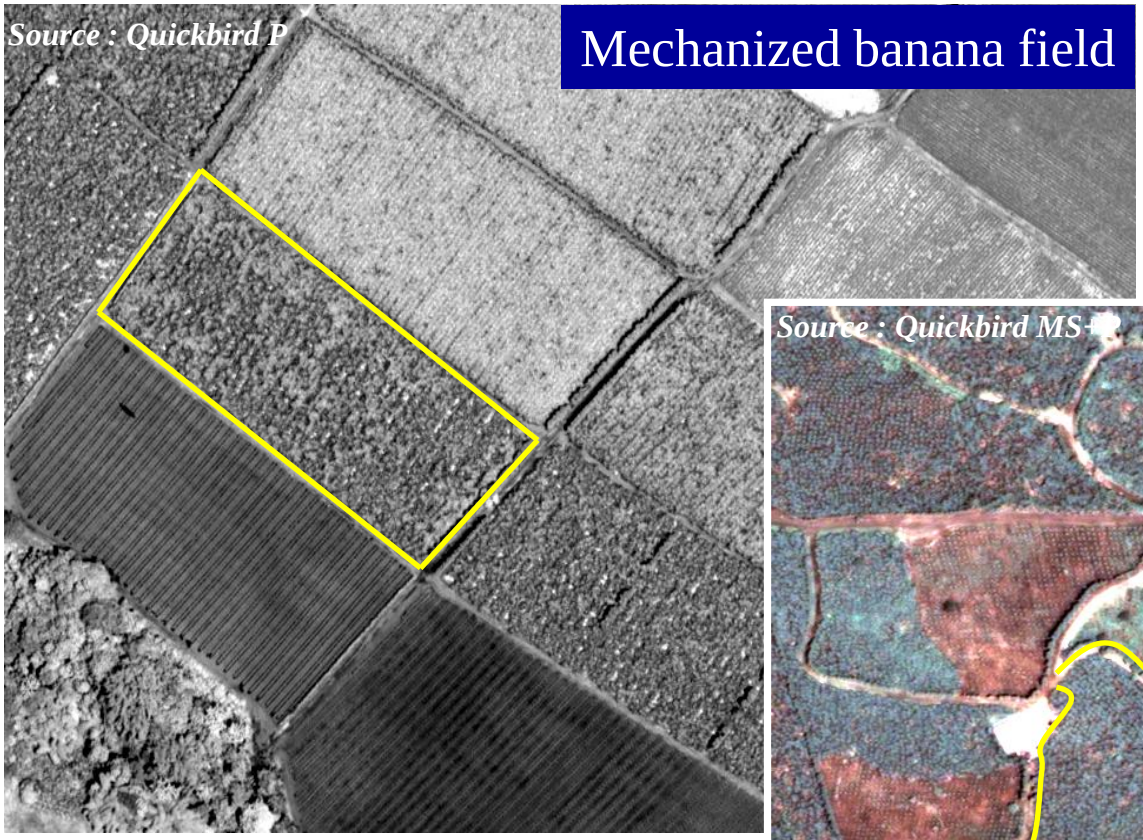
Source : G. Lainé, CIRAD

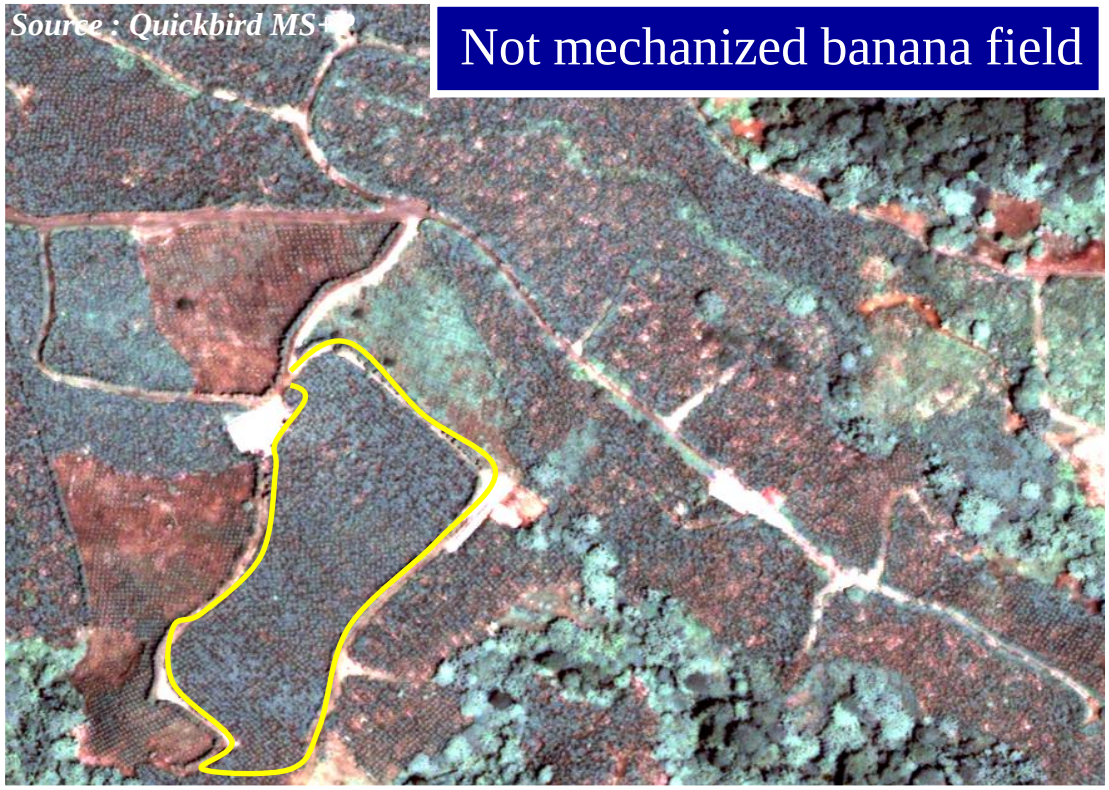
Natural vegetation

Sugarcane

Banana trees

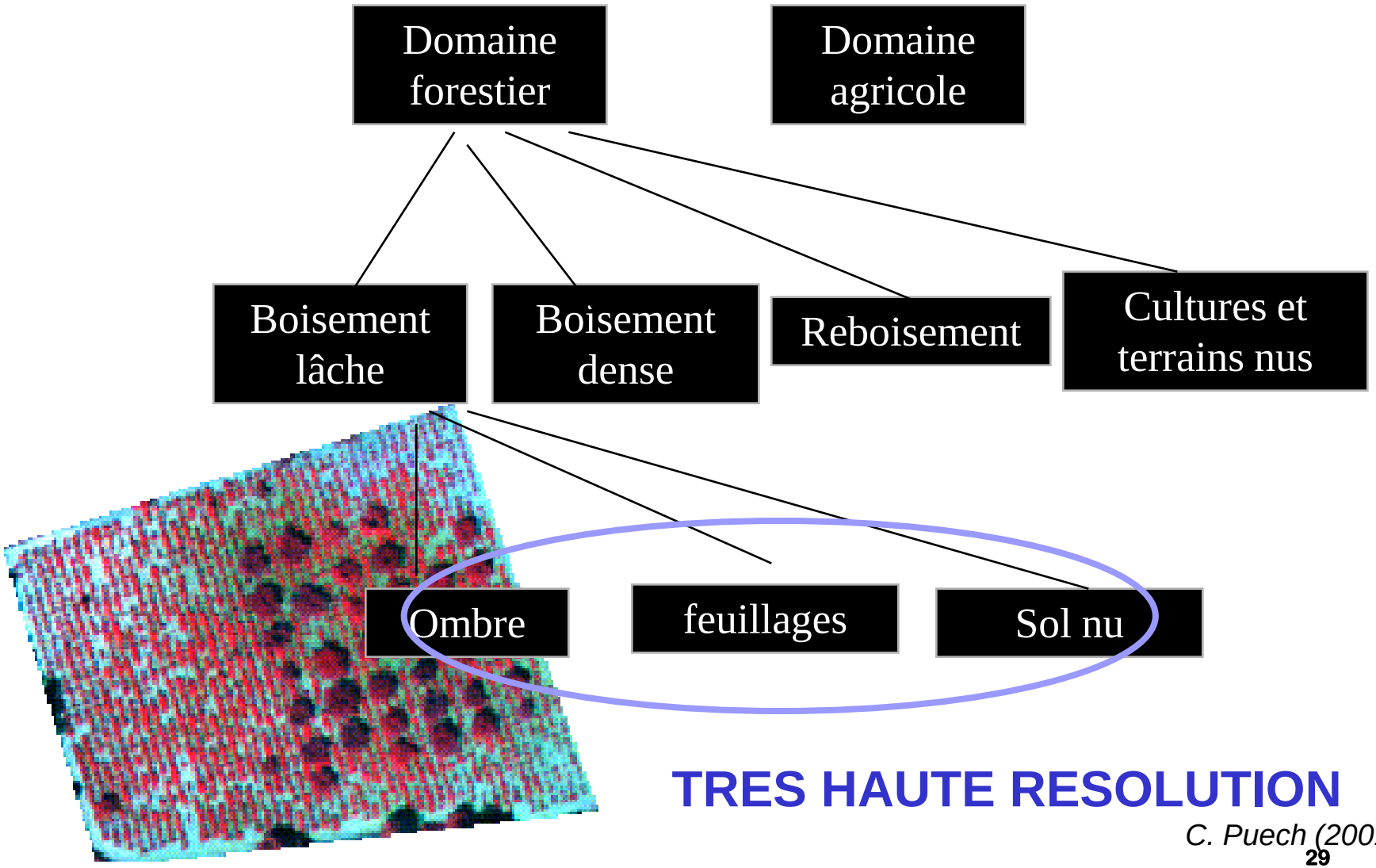
- Structural information





Source : Gérard Lainé, CIRAD

- Organisation level

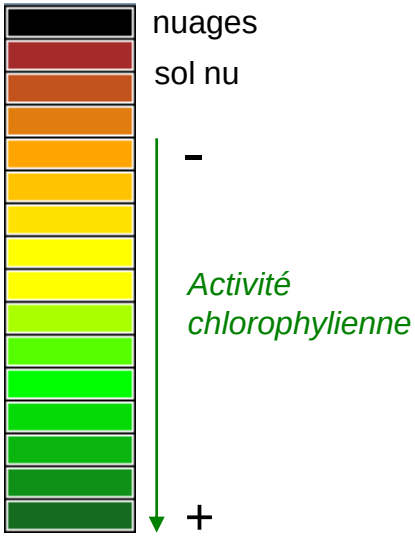


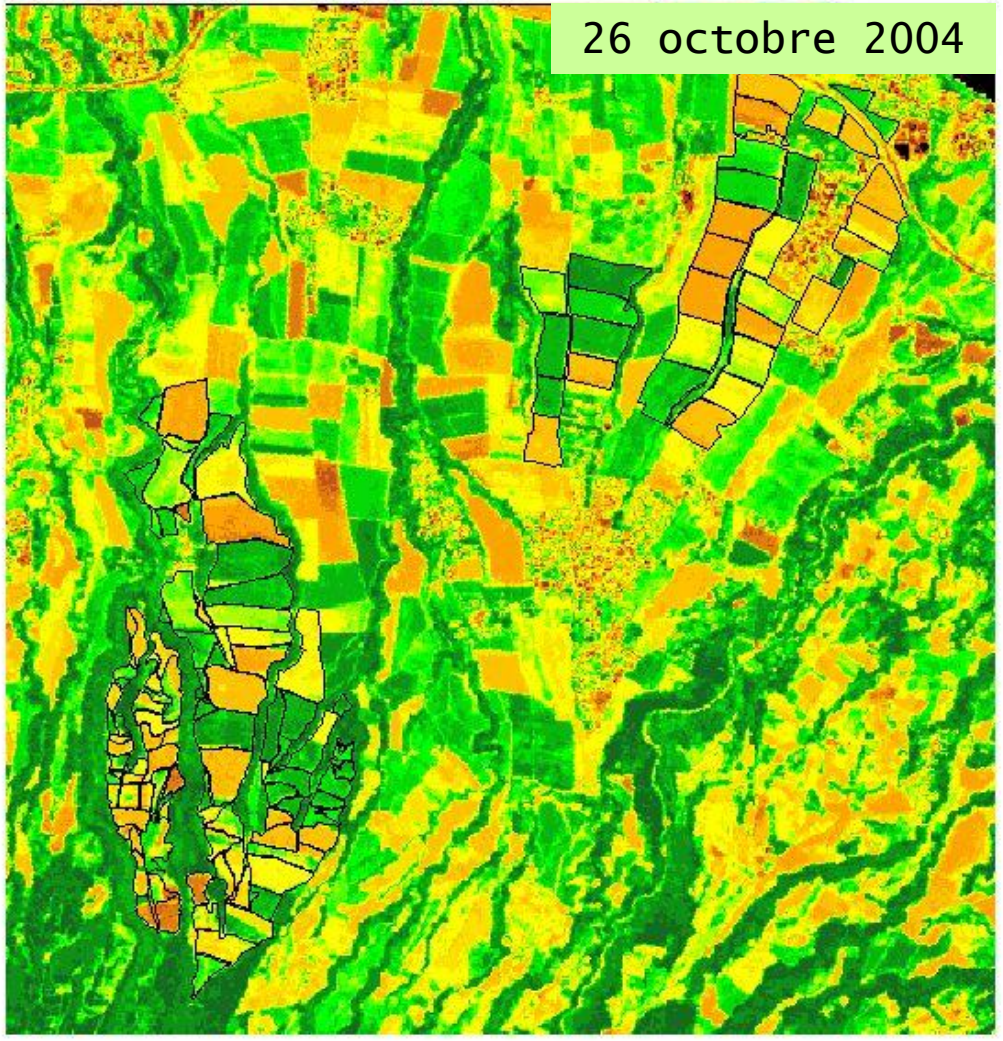
TRES HAUTE RESOLUTION

C. Puech (2001)

Temporal information (seasonal)

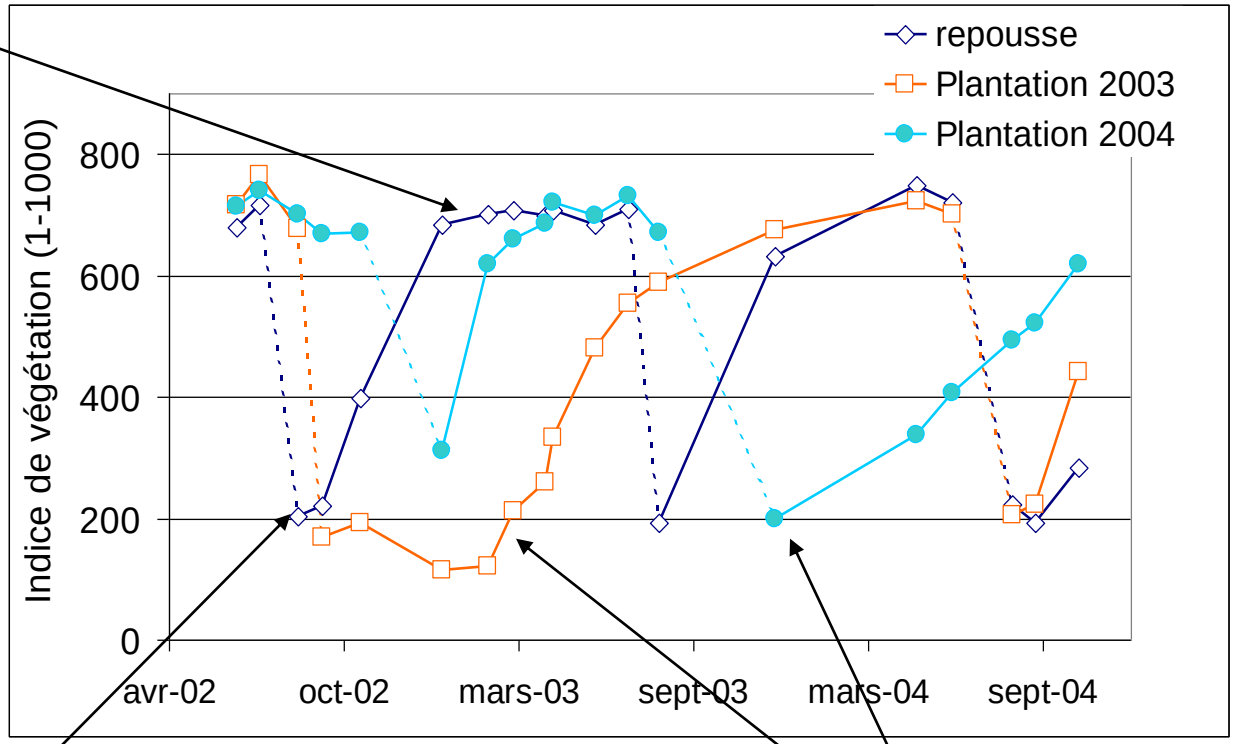
Paysage agricole
Ile de La Réunion



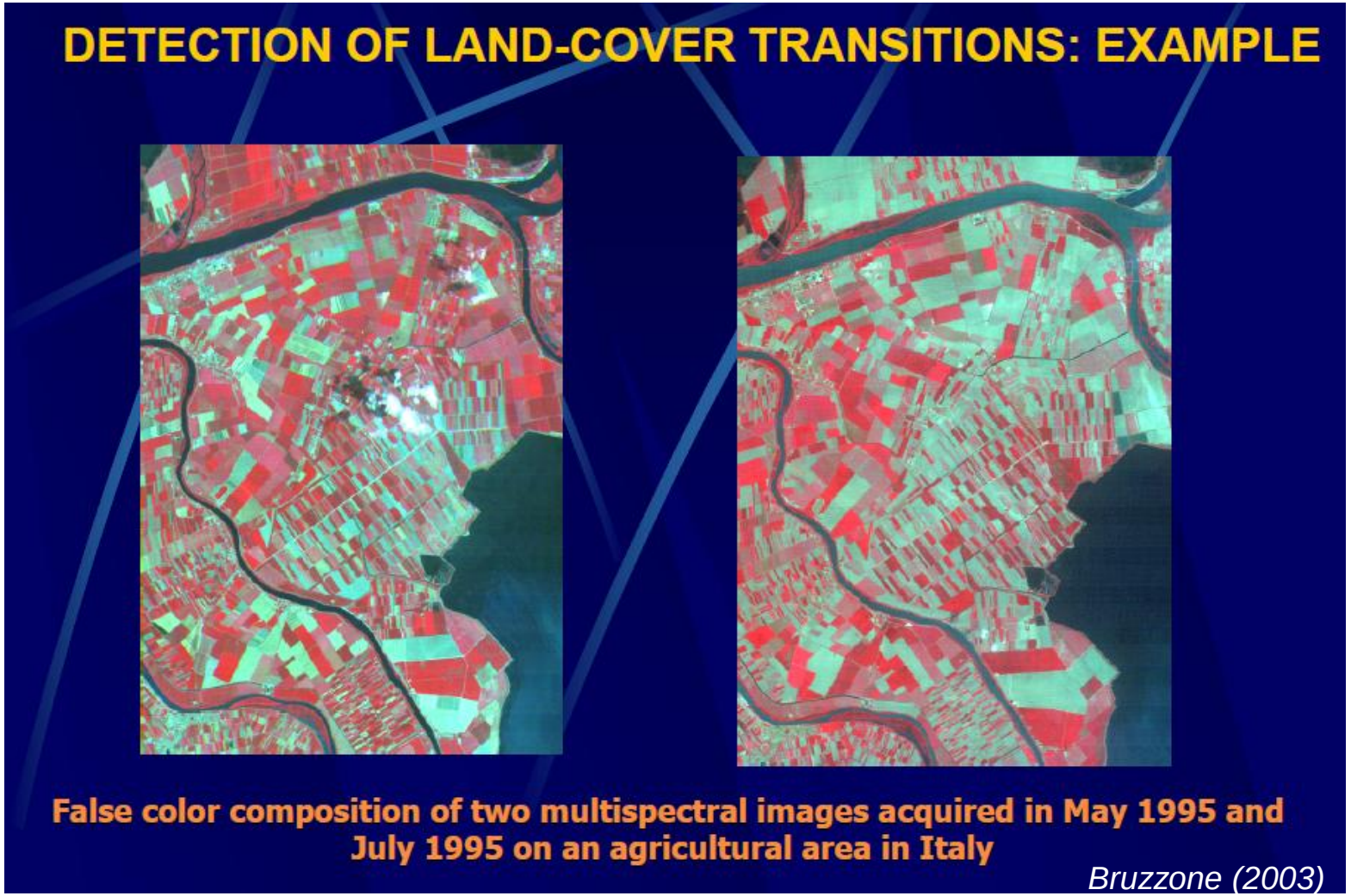


Bégué et al. (2009)

Temporal information (seasonal)



- Temporal information (annual)



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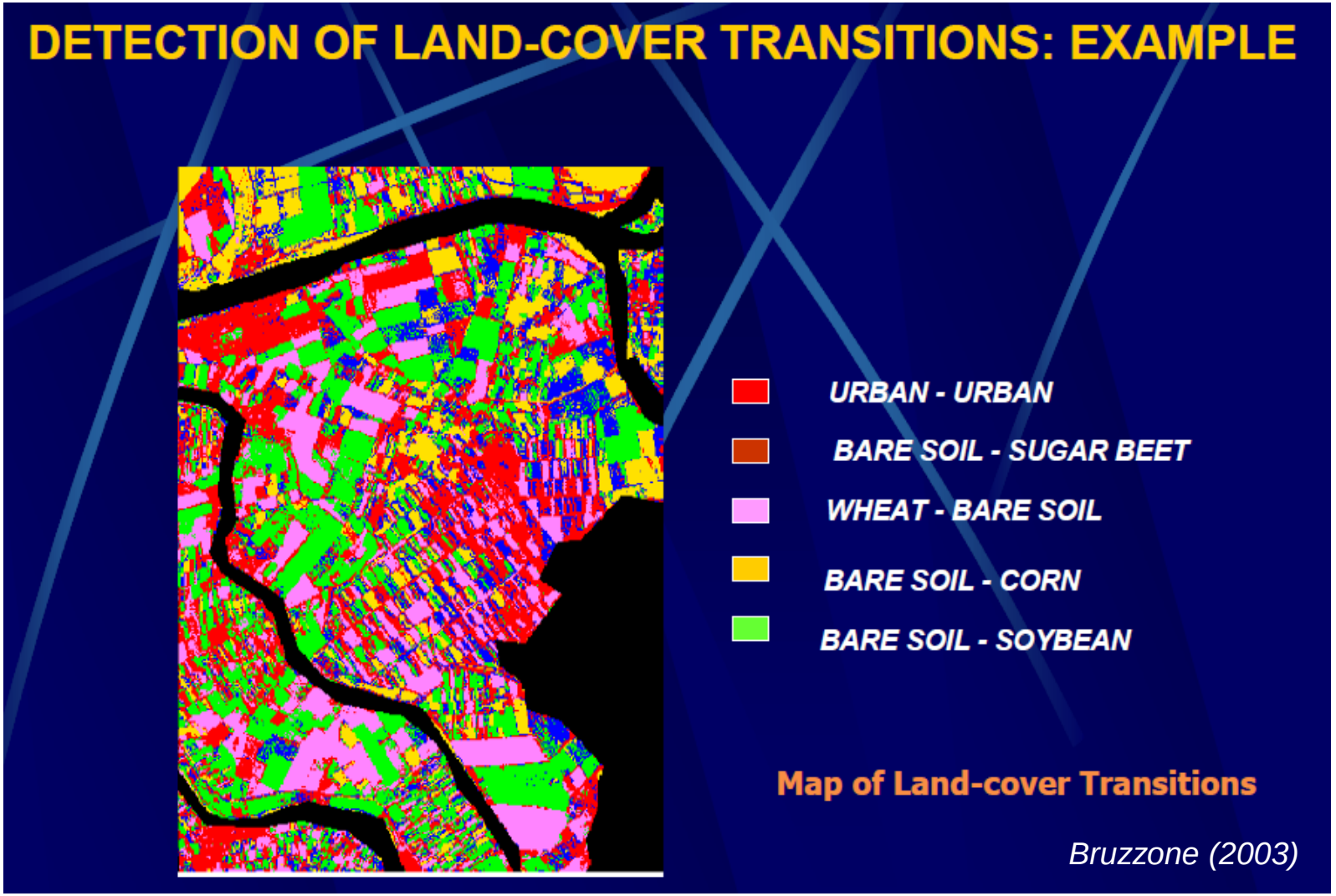


- Temporal information (mid/long term trend)

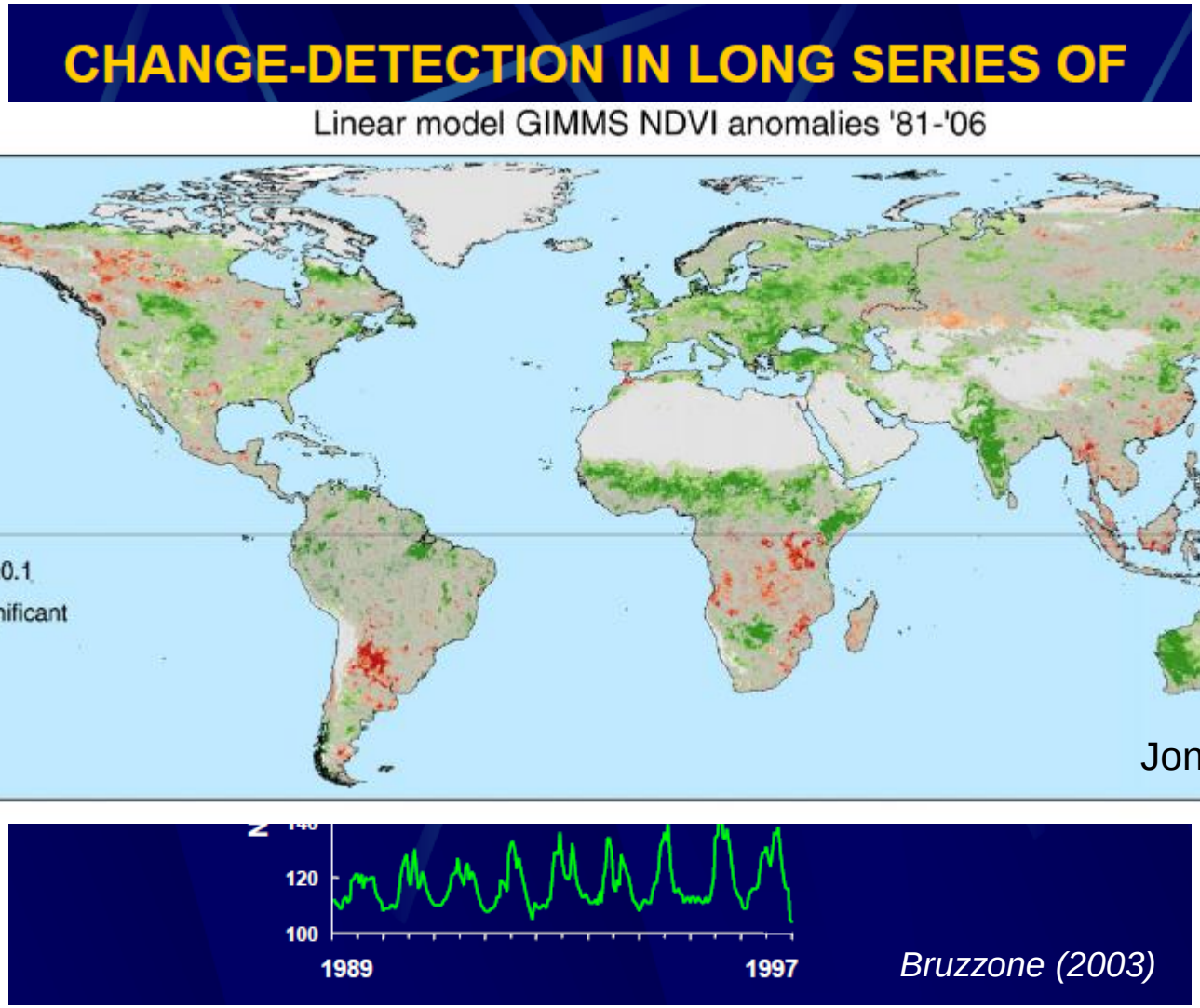
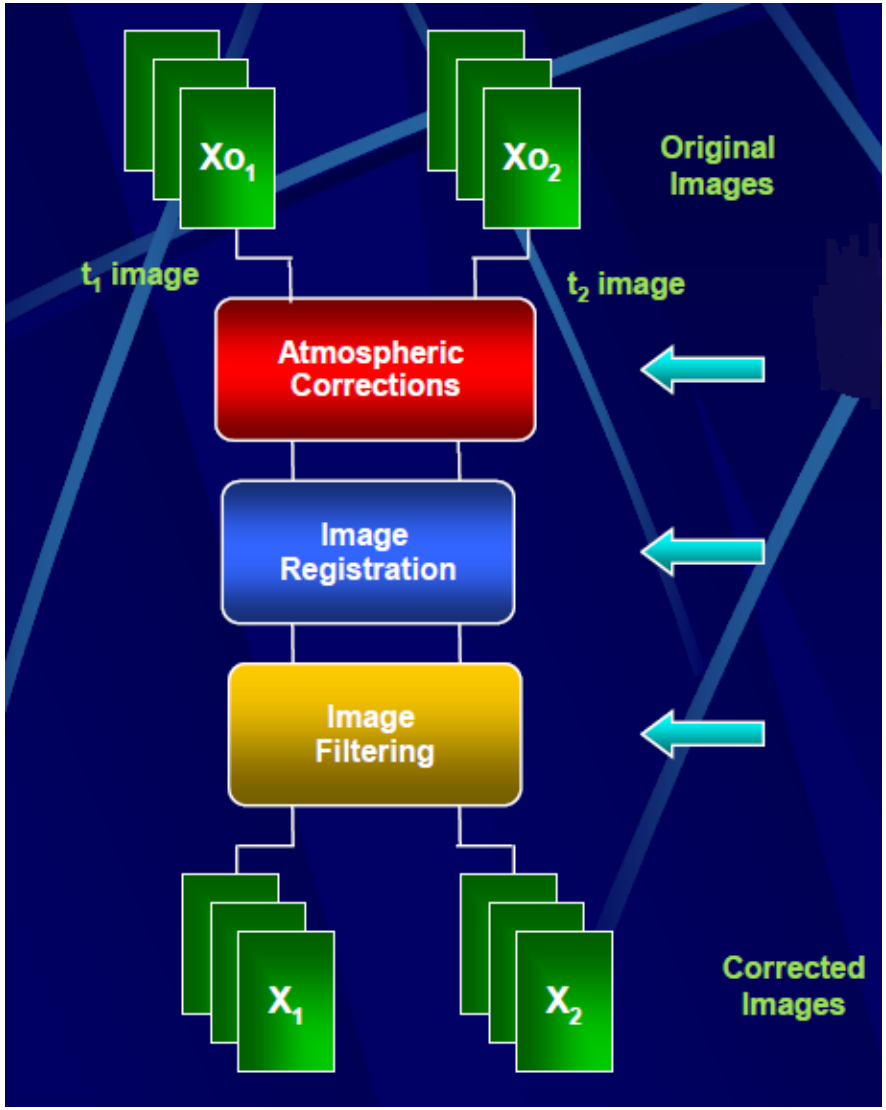


Image pre-processing



Not to be underestimated !!!

Conclusions

- **A very large offer in terms of spatial data (satellite and/or aerial images) : resolution, image size, spectral bands, repetitivity, length of time series…**
  - Increasing number of Very High Resolution satellites;
  - New satellite concepts (daily visit in High Resolution);
  - A « democratisation » of the image (Google Earth…)
  - For the « democratisation » of the costs… be patient…

- **Most of the remote sensing applications are of interest for ecology :**
  - Qualitative and quantitative description of the main landscape components (vegetation, soil, water, altiutude…), and their respective spatial distributions.